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Domestic Air Pollution and Respiratory Function in a Group of Housewives

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We determined air pollution exposure to sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and respirable suspended particulates (RSP) for a group of symptomatic housewives and a matched control group using a specially designed domestic air pollution sampler. The NO_2 and RSP levels were higher indoors than outdoors, whereas the SO_2 levels were higher outdoors. The cases and controls showed the same air pollution exposures. The use of gas stoves resulted in elevated levels of NO_2 which might account for the observed reduction in lung function of residents in homes with gas stoves. Cigarette smoking indoors resulted in elevated particulate levels. The maximum expiratory flow (MEF) at 25% and 50% of vital capacity for non-smoking housewives showed a significant correlation with indoor particulate levels. Multiple regression analyses showed that RSP was a better predictor than NO_2 of lung function changes.

A l'aide d'un appareil spécifiquement conçu pour le prélèvement de l'air domestique, on a évalué l'exposition au dioxyde de soufre (SO_2), au dioxyde d'azote (NO_2) et aux particules respirables en suspension (PRS) d'un groupe de ménagères symptomatiques et d'un groupe pairé.

Les concentrations de NO_2 et de PRS se sont avérées plus élevées à l'intérieur qu'à l'extérieur alors qu'on a observé l'inverse à l'égard des concentrations de SO_2.

Les cas et les témoins montraient des niveaux identiques d'exposition aux polluants atmosphériques.

Dans certaines maisons, l'usage de poêles à gaz a entraîné des concentrations élevées de NO_2; ceci pourrait être à l'origine de la diminution des fonctions respiratoires de ces résidents.

Le fumage de cigarettes a entraîné des concentrations élevées de particules.

On a observé une corrélation significative entre les concentrations de particules à l'intérieur et le débit respiratoire maximum (DEM) à 25% et 50% de la capacité vitale des ménagères non-fumeuses.

Enclosures afford protection from outdoor pollution, but they entrap pollutants that may have seeped inside or have been generated indoors.[1] Diffusion of pollutants from outside may account for a large proportion of indoor pollution[2,3,4] and may depend on passive and active ventilation.

Smoking, cleaning, and dusting generate a large amount of dust within the home.[5] Lefcoe et al[6] found that indoor levels decreased during the night, probably because of lower outdoor levels and lower indoor activity. Anderson[7] found a high correlation between indoor and outdoor levels for SO_2 and suspended particulate. Wade et al[8] showed that homes with gas stoves had an NO_2 source independent of outside NO_2. Other researchers have also found gas stoves to be a source of NO_2 in homes.[9] Cigarette smoking indoors accounts for a large portion of suspended particulates.[10-16]

Other internal sources of pollution are aerosol sprays, heaters, humidifier systems, degrading surfaces, dried and scaling epidermis, hairs and foods.[15,16]

The evaluation of domestic factors may help to explain some of the causal factors in respiratory diseases. Reid[17] found that domestic crowding was associated with coryza. Others[18-21] have found crowding to be a causal factor in respiratory disease.

Colley[19] showed that parental smoking had only a small effect in children's respiratory symptoms, but other studies have shown an indirect effect of smoking.[22,23,24] A few studies showed no effects from passive smoking[25,26] but others showed a direct effect on symptoms[27-31] and lung function.[32,33]

The use of hair spray resulted in generation of aerosols[34] which was not associated with lung function changes, but

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resulted in reduced mucous velocity and chest tightness. In a provocation study, test subjects showed a reduction in maximum expiratory flow,[37] and in an epidemiological study, aerosol spray usage was found to be correlated with respiratory symptoms.[38]

The growth of bacteria and fungus in humidification systems may result in exposure to viable aerosols.[39,40]

Keller et al[41] found no excess illnesses in residents who had gas stoves as compared to those with electric stoves, but children in houses with gas stoves had more bronchitis, cough and chest colds.[42,43] Some researchers have shown an effect of using gas stoves on lung function.[42,44,45]

Binder et al[41] found no association between exposure levels and lung function or symptoms in a group of children.

We studied exposure to three air pollutants, sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and respirable suspended particulates (RSP) in a group of housewives with respiratory symptoms; we compared the exposure with a matched group with no symptoms. Our aim was to determine whether domestic exposure was a factor in symptom causation; and to determine if a correlation existed between lung function and pollution levels.

METHODS

Exposure Measurement

Ambient air quality can be assessed with stationary sampling instruments. These characterize the air around the instruments but difficulties arise when the results of such measurements are used to estimate true exposure of subjects who move around, both outdoors and indoors. To obtain air quality data that might more adequately reflect an individual's changing environment, an easily portable, lightweight, and low-noise air-sampling instrument that allowed individuals to monitor their domestic environment during 24-hour periods was designed.

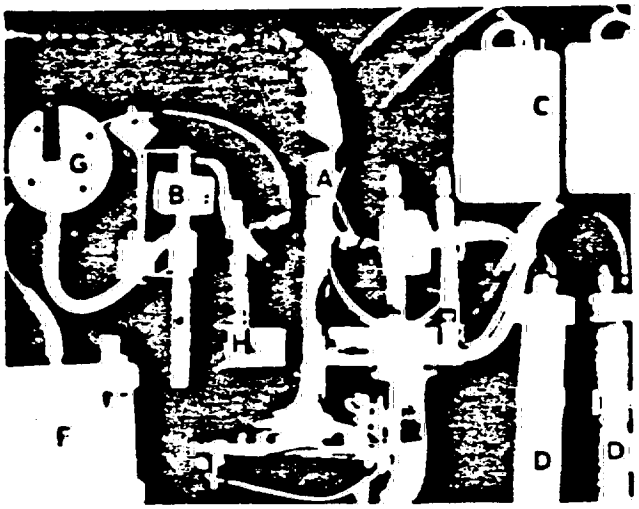

Figure 1. Multipollution Sampler for SO_2, NO_2 and RSP

A. Main Sampling Mainfold
B. RSP Filter with Nylon Cyclone
C. Low Flow Pumps for SO_2 and NO_2
D. Tubes with Absorbing Solution for SO_2 and NO_2
E. Main Blower Pump for Mainfold
F. Pump for RSP
G. Dampener for RSP Pump
H. Flow Meters

The instrument consisted of a manifold connected to a high volume blower which served as the main sampling source (Figure 1). Probes from the manifold led to (a) a dust sampler fitted with a cyclone assembly to collect respirable size particulates (less than 10 μm) on to a fiberglass filter, (b) an impinger with a solution of potassium tetracholomercurate to absorb sulfur dioxide, and (c) another impinger with sodium hydroxide solution to absorb nitrogen dioxide. The samplers were housed in a suitcase 50 x 38 x 15 cm weighing 7 kg (16 lbs). The concentration for RSP was determined by gravimetric analysis, and SO_2 and NO_2 were determined by colorimetric methods.[46,47] The detection limits for RSP, SO_2 and NO_2 were 5 $\mu g\ m^{-3}$, 3 $\mu g\ m^{-3}$ and 10 $\mu g\ m^{-3}$ respectively, and the recovery rates were 100%, 35% and 35%; the appropriate corrections were made for SO_2 and NO_2 recoveries.

The domestic sampling was conducted once in the summer and once in the winter. The duration of sampling each time was 24 hours.

Simultaneously, outdoor sampling for the same pollutants was conducted within a radius of 1.6 km.

Subjects were telephoned and advised that this study was a follow-up to the larger study in which they had participated earlier. A mutually agreeable time was arranged for the domestic sampling; in all cases, sampling was conducted in the homes of the cases, controls and outdoors during the same 24 hour period.

The sampler was placed in an area most used by the subject and at a height close to the breathing zone (about 1.2m). They were advised to perform all their chores normally and to report any abnormal situations that might influence their exposure over that 24-hour period.

A short questionnaire ascertained their respiratory symptoms, smoking habits, use of heating or cooling systems, cooking methods, hobbies, housekeeping, the presence of smokers, and health conditions of others in the same house.

Subject Selection and Health Status Measurements

Housewives 25-44 years were selected for this study because they spend most of their time at home. A symptomatic group was chosen, all members responding positively to questions on "usual cough" and "usual phlegm". These subjects were matched with controls of similar age (± 5 years), who had similar smoking habits but answered negatively to the questions on "usual cough" and "usual phlegm".

These subjects were participants in a larger epidemiological study of over 7,000 people from three U.S. communi-

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ties.[29,30,31] The subjects were selected from two towns: Lebanon, Connecticut, and Winnsboro, South Carolina. A modified National Heart and Lung Institute questionnaire was used to determine respiratory symptoms, respiratory diseases, smoking habits, occupational exposures, domestic exposure, and sensitivities to allergens.[32] Pulmonary function tests were conducted in a mobile laboratory using expiratory flow volume equipment. Five expirations were made into a pneumotachograph by each subject; the two expirations with best forced expiratory volume in one second (FEV_1) were used in computing the mean lung function.

The maximum expiratory flow volumes at 25% and 50% of vital capacity ($Vmax_{25}$ and $Vmax_{50}$) associated with these two expirations were also computed.

Calibration

The sampling equipment for SO_2 and NO_2 was calibrated against permeation tubes traceable to National Bureau of Standards. For RSP, the comparison was made against a direct reading tape sampler. This calibration was conducted in the laboratory. In all cases there were significant correlations between the sampling methods and the three comparison methods respectively ($r = 0.99$ for SO_2 and NO_2 respectively and $r = 0.88$ for RSP). SO_2 was calibrated at 5 points between 3 and 40 $\mu g\ m^{-3}$; NO_2 was calibrated at 7 points between 10 and 80 $\mu g\ m^{-3}$, and RSP was calibrated at 8 points between 20 and 80 $\mu g\ m^{-3}$.

The volume displacement of the maximum expiratory flow volume equipment was checked using a constant

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TABLE I

Comparison of Domestic and Outside Environments for Air Pollutants, Lebanon, Connecticut

Pollutant	Smoking Category (# of pairs)	Season	Exposures ($\mu g\ m^{-3}$)* Domestic: Airway Symptoms	Domestic: Control	Outside
SO_2	non-smokers (7)	Winter	6.2 ± 1.7	4.6 ± 1.9	17.6 ± 2.0
		Summer	4.2 ± 2.2	1.6 ± 6.8	8.7 ± 1.5
	smokers (7)	Winter	1.9 ± 7.6	3.5 ± 7.8	6.2 ± 1.8
		Summer	0.6 ± 10.3	1.7 ± 8.1	1.6 ± 3.7
NO_2	non-smokers (7)	Winter	80.9 ± 1.5	74.2 ± 1.6	63.9 ± 1.3
		Summer	86.4 ± 1.8	88.6 ± 1.5	51.7 ± 1.4
	smokers (7)	Winter	206.7 ± 1.9	128.6 ± 1.9	43.0 ± 1.7
		Summer	103.9 ± 1.4	124.1 ± 2.1	16.1 ± 1.7
RSP	non-smokers (7)	Winter	54.2 ± 3.1	38.6 ± 2.0	27.8 ± 1.5
		Summer	39.6 ± 1.5	31.0 ± 1.6	31.5 ± 1.5
	smokers (7)	Winter	101.6 ± 1.7	105.3 ± 1.9	22.6 ± 1.6
		Summer	103.8 ± 1.4	91.2 ± 1.5	28.7 ± 1.9

*in geometric mean ± geometric standard deviation

TABLE II

Comparison of Domestic and Outside Environment for Air Pollutants, Winnsboro, South Carolina

Pollutant	Smoking Category (# of pairs)	Season	Exposures ($\mu g\ m^{-3}$)* Domestic: Airway Symptoms	Domestic: Control	Outside
SO_2	non-smokers (4)	Winter	5.3 ± 5.0	9.6 ± 5.0	23.3 ± 2.2
		Summer	1.3 ± 1.7	0	1.7 ± 2.8
	smokers (8)	Winter	2.8 ± 2.6	4.9 ± 3.5	36.6 ± 1.6
		Summer	0	0	1.5 ± 2.3
NO_2	non-smokers (4)	Winter	70.9 ± 1.6	75.9 ± 1.3	17.9 ± 1.1
		Summer	48.6 ± 3.5	86.9 ± 2.7	18.3 ± 1.2
	smokers (8)	Winter	95.7 ± 2.1	103.1 ± 1.9	17.6 ± 1.4
		Summer	87.1 ± 1.4	82.9 ± 1.7	21.1 ± 1.3
RSP	non-smokers (4)	Winter	58.0 ± 1.1	50.6 ± 2.6	31.1 ± 75.4
		Summer	33.1 ± 3.1	25.0 ± 31.6	75.4 ± 1.3
	smokers (8)	Winter	54.1 ± 1.6	42.3 ± 2.7	21.8 ± 1.9
		Summer	78.5 ± 1.4	48.0 ± 4.4	55.5 ± 1.4

*in geometric mean ± geometric standard deviation

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TABLE III
Nitrogen Dioxide Levels in Homes with Gas and Electric Stoves

	Gas		Electric	
	Winter	Summer	Winter	Summer
No. of observations	11	11	41	41
Geometric Mean ($\mu g\ m^3$)	214.7	179.5	80.6	76.6
Geometric Standard Deviation	1.97	1.56	1.62	1.78
Unpaired t-test (Gas vs Electric)	$p < .001$			

volume syringe. A cam arrangement, which mimicked a typical flow volume output, was used to check the expiratory flow rates.

RESULTS

Tables I and II summarize the air pollution data for the subjects in the two towns during the winter and summer for the two smoking categories. The air pollution summary data for SO_2, NO_2 and RSP are given as geometric means since air pollution levels usually follow a log normal distribution.

The summary air pollution exposure data for the housewives in Lebanon and Winnsboro are shown in Tables I and II. When the data for the housewives with symptoms were compared against those without symptoms, no statistically significant differences were found. To determine whether the domestic exposure was different from the outdoor exposure the data for both housewives' groups were combined and compared against the outside air pollution data; this comparison revealed in general that the SO_2 levels were usually higher outdoors, whereas the NO_2 and RSP levels were higher indoors.

In Lebanon, the homes of smokers showed higher levels of NO_2 and RSP than the homes of non-smokers. In general the winter air pollution levels in the Lebanon homes were higher than the summer levels. In Winnsboro, the homes of smokers did not show any consistent trends, nor were there any trends between the levels in the homes during winter or summer. 21% of the homes had gas stoves, and in these NO_2 levels (Table III) were significantly higher than in homes with electric stoves ($p < .001$). This differential between homes with gas and electric stoves was seen in both seasons.

TABLE V
Effect of Gas Stove Cooking on the Lung Function of Non-Smoking Housewives

	Mean Lung Function ± Standard Deviation*			
	N	MF_{25}	MF_{50}	FEV_1
Gas Stoves	3	-32.5 ± 25.0**	-32.0 ± 26.0**	-25.3 ± 26.2*
Electric Stoves	19	-1.3 ± 15.9	-2.7 ± 13.*	-2.2 ± 14.9

Unpaired t-test between gas and electric stove users. * = $P < .05$, ** = $P < .01$
* the mean values reported are the percent deviation from predicted

The winter NO_2 levels were higher than the summer NO_2 levels in homes with both gas and electric stoves. Air-conditioned homes with gas stoves had a mean NO_2 level of 175 $\mu g\ m^3$ ($n = 4$) whereas the non-air conditioned homes with gas stoves had a mean level of 182 $\mu g\ m^3$ ($n = 7$).

5% of the homes had gas radiant heaters, but some also had gas stoves, hence it was not possible to assess the emissions of NO_2 from this source. The homes of smokers without gas stoves had a mean NO_2 level of 83 $\mu g\ m^3$ whereas homes of non-smokers without gas stoves had a mean level of 76 $\mu g\ m^3$ in the winter season; the differences were significant ($p < .001$). In the summer the means were 76 and 75 $\mu g\ m^3$ respectively.

The tests to determine the daily variations in domestic NO_2 loading showed that in two homes with gas ranges, the NO_2 levels were sometimes in excess of 1000 $\mu g\ m^3$ (i.e., 2-hourly values). In one home, 13 of the 60 2-hourly values were in excess of 1000 $\mu g\ m^3$. In this latter home, peak 2-hourly values in excess of 3000 $\mu g\ m^3$ were observed on two separate occasions. In all cases, these peaks were directly related to extensive use of the gas stoves and ovens.

Cigarette smoking contributed significantly to the RSP loading within the homes in the winter and summer (Table IV). The presence of one smoker in the home resulted in significantly more RSP than in homes with no smokers ($p < .001$), and in homes with 2 or more smokers the RSP levels were higher than homes with one smoker or no smokers ($p < .001$). In air conditioned homes with at least one smoker the mean RSP level was 81 $\mu g\ m^3$ ($n = 11$) whereas the mean RSP level in homes without air conditioning was 70 $\mu g\ m^3$ ($n = 25$).

Homes with hot water heaters with no smokers had significantly higher levels of RSP (mean 67 $\mu g\ m^3$) than homes with forced air (mean 38 $\mu g\ m^3$).

TABLE IV
Respirable Suspended Particulates as a Function of Smoking

	Number of Smokers in the Home					
	Winter			Summer		
	0	1	≥ 2	0	1	≥ 2
No. of Observations	14	18	18	14	18	18
Geometric Mean ($\mu g\ m^3$)	40.9	47.9	75.6	35.2	56.8	84.*
Geometric Standard Deviation	2.03	2.4*	2.06	1.6*	1.79	1.50
Unpaired t-test	$P < .001$		$P < .001$	$P < .001$		$P < .001$

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TABLE VI

Lung Function of Non-Smokers Living in Homes of Smokers and Non-Smokers as a Function of Cooking Fuel Used

Pks day # Electric Stove Home	N	Mean ± Standard Deviation * $MF_{25\%}$	$MF_{50\%}$	FEV_1
0	36	- 4.0 ± 15.7	- 0.2 ± 12.4	-1.9 ± 13.3
1	36	- 6.7 ± 16.5	- 3.0 ± 12.0	-0.6 ± 15.8
2+	23	- 5.9 ± 16.0	- 1.6 ± 10.9	-1.4 ± 23.9
Pks day # Gas Stove Home	**N**	$MF_{25\%}$	$MF_{50\%}$	FEV_1
0	6	-12.6 ± 21.2	- 8.5 ± 25.3	-9.0 ± 20.9
1	2	-2.2 ± 9.1	-14.6 ± 6.1	-9.8 ± 11.3
2+	11	- 7.0 ± 14.8	- 7.9 ± 11.1	-6.3 ± 14.1

#Packs of cigarettes smoked indoors
0 = no smoker in the home
1 = 1 pk day of cigarette smoked in the home
2+ = 2 or more pks day of cigarette smoked in the home
* = See footnote, Table 5
There were no significant differences between the smoking groups for each lung function variable

To determine whether the NO_2 exposure from gas stoves resulted in impairment of lung function, non-smokers in homes with gas stoves were compared with their counterparts in homes with electric stoves (Table V). Housewives using gas stoves had significantly lower $Vmax_{25\%}$, $Vmax_{50\%}$ and FEV_1. However, the number of housewives in the gas stove user group was small (n = 3).

In the housewives study group, 31% of the subjects with symptoms used gas stoves, whereas 12% who used electric stoves showed symptoms. Comparing all subjects (ie., children and adults) within these homes, 28% of the gas stove users showed symptoms whereas 18% of electric stove users showed symptoms. Both these comparisons included smokers and non-smokers.

The lung function of non-smokers who lived in homes with (a) no smokers, (b) a smoker who smoked one pack per day, and (c) a smoker who smoked two or more packs per day, were compared. In this comparison all members of the household were included and this total group was separated into those who lived in homes with electric stoves and those who lived in homes with gas stoves. In general, the lung function of non-smokers who lived in homes with electric stoves was not influenced by passive smoke (Table VI).

The lung function of non-smokers who lived in homes with gas stoves did not appear to be affected by passive smoke, but the numbers in each smoking category was small (Table VI). The degree of correlation between the indoor air pollutants and lung function was investigated for the housewives group (non-smokers) and for all no-smoking residents in the homes of the housewives group. The analyses were conducted for NO_2 and RSP and the lung function variables of $Vmax_{25\%}$, $Vmax_{50\%}$ and REV_1. SO_2 was not compared because of the extremely low indoor levels. The correlation was conducted between the log of the pollution values and the percent deviation of the lung function measures from the predicted values.

For non-smoking housewives, there were negative correlations between log NO_2 and the lung function variables, but none of these were statistically significant (Table VII).

This group also showed negative correlations between RSP and the lung function variables, two of them being statistically significant i.e., $Vmax_{25\%}$ ($p < .05$) and $Vmax_{50\%}$ ($p < .05$) (Table VII). When all residents of the homes were studied, the effect of NO_2 on lung function was negligible, but the effect of RSP was significant for $Vmax_{50\%}$ ($p < .05$). For smokers there were no associations between exposure to NO_2 and RSP and lung function; an indication that the effect of smoking may overide any effects of the other pollutants in the home.

There was no association between the NO_2 and RSP values.

An attempt was made to determine whether the pollutants, NO_2 and RSP, acting together would explain more of the effects on the lung function parameters. A statistical Analysis System (SAS) data set was created from the log values for NO_2 and RSP and for the percent deviation of the lung function parameters from their predicted values. A multiple regression analysis was conducted on smokers and non-smokers, for housewives, and for all residents of the homes.

The regression analysis for non-smoking housewives showed that RSP was a better predictor than NO_2 of lung function changes (Table VIII). When both NO_2 and RSP were included in the multiple regression, a larger proportion of the variation was explained, and RSP was a better predictor of $Vmax_{25\%}$ ($p < .05$) and $Vmax_{50\%}$ ($p < .05$); the effect on FEV_1 was not significant.

TABLE VII

Correlation Between Indoor Pollutants and Lung Function of Non-Smokers and Smokers

Non-Smokers	Correlation Coefficient (r) Housewives only $MF_{25\%}$	$MF_{50\%}$	FEV_1	All residents in the home $MF_{25\%}$	$MF_{50\%}$	FEV_1
NO_2	- .29	- .34	- .23	- .07	- .04	- .04
RSP	- .41*	- .41*	- .31	- .28	- .45*	- .39*
NO_2	- .14	- .25	- .13	- .09	- .14	- .27
RSP	- .09	- .19	- .11	- .06	- .30	- .31

* The correlation was done on the log of the pollution concentration and the percent deviation of the lung function value from the predicted value
* $P < .05$

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TABLE VIII

Multiple Regression of Lung Function on NO_2 and RSP of Non-Smokers and Smokers

Non-Smokers Variable	Percent of Variation Explained by Variable (R^2)					
	Housewives Only			All Residents		
	MF_{25}	MF_{50}	FEV_1	MF_{25}	MF_{50}	FEV_1
Non-Smokers						
NO_2	8	11	5	1	1	6
RSP	1*	1*	9	8	20*	15
NO_2 & RSP	29*	34*	1*	9	20*	15
Non-Smokers						
NO_2	2	6	2	1	2	-
RSP	8	4	1	1	9	9
NO_2 & RSP	3	11	3	1	12	15

* $P < .05$
† Only RSP was acting separately to explain the lung function

TABLE IX

Daily Variation of TSP and NO_2 in the Domestic Environment

Mean 24-hour Concentration	Day 1	Day 2	Day 3	Day 4	Day 5	F-test*
TSP**	.027	.024	.015	.036	.021	1.53 •
NO_2 ($\mu g \cdot m^3$)	38	36	30	26	44	2.59••

*F-value from one way analysis of variance • $P > 0.05$; •• $P = 0.05$
**TSP levels are expressed in COH Units (coefficient of haze). For this comparison a continuous particulate tape sampler was used

When all the non-smoking residents were tested, RSP was again found to have the major effect on lung function, especially on $Vmax_{50}$; the effect of NO_2 was less predominant than in the housewives group (Table VIII).

For smoking housewives, and for all smoking residents, the multiple regression analysis did not show any significant effects between lung function and the pollution values.

DISCUSSION

The domestic environment had its own generating sources for NO_2 and RSP, so much so that the levels of these two pollutants indoors were significantly higher than outdoors. Yocom et al[3] found higher NO_2 levels in homes with gas cookers and Dockery et al[12] found higher RSP indoors than outside. For commercial buildings, the indoor outdoor ratios were less than unity.[13,14] The observed differences in this study may be relevant only to the rural environment since both towns had rural characteristics. It is possible that in urban environments, the indoor outdoor ratio may be less than unity.

Housewives living in homes with gas stoves had more exposure to NO_2 than those in homes with electric stoves. In some cases the concentration was observed to be as high as 3000 $\mu g \cdot m^3$, which potentially could cause acute respiratory reactions.[15] Chronic exposure to low levels of NO_2 may result in loss of lung function and increased symptom reporting.[16,17] Homes with gas stoves had approximately 100 $\mu g \cdot m^3$ more NO_2 than homes with electric stoves.

The presence of one smoker in the home increased the RSP loading by 8 $\mu g \cdot m^3$ in the winter and 20 $\mu g \cdot m^3$ in the summer; two smokers in the home increased the levels by 35 and 50 $\mu g \cdot m^3$ in the winter and summer respectively.

Dockery et al[12] found similar increases but Repace[11] and Weber[18] found much higher levels. Smoking in air conditioned homes resulted in slightly higher levels of RSP compared to homes without air conditioning. Cigarette smoking indoors contributed about 2 $\mu g \cdot m^3$ of NO_2 in the summer and 7 $\mu g \cdot m^3$ in the winter.

The simple linear regression analysis between NO_2, RSP and the lung function variables in non-smokers showed that RSP correlated well with lung function depression. The multiple regression analysis indicated that both NO_2 and RSP acted separately on the lung, but RSP was a better predictor of lung function changes than NO_2.

The uniformity of smoking, cooking fuel use, indoor activity and type of heating system may account for the lack of differences in the mean air pollution levels between the normal and symptomatic housewives' group. Perhaps the number of subjects was too small to produce statistically significant differences in exposure levels between the cases and controls; we could not control the number of cases since only 26 met the selection criteria. The sampling schedule once in the winter and once in the summer might have been too small to define the domestic exposure because of daily variation. We tried to determine whether there was significant variation between days by sampling in a home for 5 consecutive days using direct reading instruments for suspended particulates NO_2 and SO_2. The findings indicated (Table IX) that there was no significant variation between days for suspended particulates; the variation for NO_2 was just at the 5% significant level; and the levels of SO_2 were non-detectable. Hence the use of 2 sampling periods appear

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to be adequate in defining domestic exposure for particulates and to a lesser extent NO_2.

Acknowledgements

This research was undertaken at the Lung Research Center, Yale Medical School, New Haven, Conn 06510 and was supported by the National Heart, Lung and Blood Institute, United States Public Health Service (HL 14179, HR42912, and HL 21352). Mr Charles Beaudry assisted in translating the title and abstract.

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Received: May 10, 1984
Accepted: October 29, 1985

2023381035

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